ARRANGEMENT AND ORGANIZATION OF TOILET FACILITIES*

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Technical domain

The invention relates to the technical field of breakdown and organization of compartmentalized service units, i.e. areas technically delimited in space, such as toilet facilities. The invention relates thereby to an improved utilization of these service units and related reduced operating costs, by means of improved techniques for controlling access thereto.

State of the art

Compartmentalized service units are areas situated in space that are associated with a functionality to serve a user. Examples of service units or stalls are units for toilet facilities, such as toilet stalls, urinals or sinks. Still other examples are fitting rooms, such as those in clothing stores, or locker rooms, such as those in swimming pools, gymnasiums, saunas, and professional environments. Still other examples are shower stalls, such as those found in swimming pools, gymnasiums, saunas, and professional settings. Further examples are seats in waiting rooms or galleries. Further examples are parking spaces.

Such service units tend to be statically arranged and organized. Many times, accessibility is controlled by permanent visual indicators such as signs. Often there is no monitoring of the use of the service units.

WO2009061857A2 and WO2014035308A1 describe a monitoring of the use of the service units being toilet facilities but do not focus on the arrangement and organization of toilet facilities. They also do not focus on controlling access.

A problem with the above approaches is that they do not account for the random behavior of users across service units, and the associated operational costs.

Another problem is that they do not address requirements related to *social distancing* and/or other measures to prevent the spread of infectious diseases at the level of service units, which further increase operational costs.

Another problem is that they do not adequately account for *social distancing* and/or other measures to prevent the spread of infectious diseases on the way to and from the service units.

Nor do they offer efficient use of service units.

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Summary

In a first aspect, the invention provides a method for controlling an accessibility with respect to a plurality of compartmentalized service units, said method comprising the steps:

- monitoring a state of use of a first of said service units;
- upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa; generating a signal indicative of said change;
- upon detection of said signal, switching the accessibility of a second of said service units different from said first service unit;

whereby said switching of accessibility of the second service unit occurs between at least two of a plurality of accessibility modes including at least two of "fully accessible", "conditionally accessible", and "inaccessible".

In preferred embodiments, the compartmentalized service units relate to toilet facilities.

An advantage of such accessibility control is the dynamic nature of accessibility, which leads to more efficient use of service units than static accessibility. The inventor has found that the operational cost of service units can be significantly reduced by ordering subsequent services. This ordering makes it possible to reduce the operational cost associated with the normal, random behavior of users. The reduced operational cost may hereby, for example, relate to a reduced average waiting time for users and/or a longer average time until the first breakdown and/or a longer *uptime* at maximum capacity and/or an improved trade-off between waiting time and *uptime*.

There are several examples where the random behavior of users leads to increased cost, which can be reduced by the invention. For example, there are situations where users want and/or need to keep a certain mutual distance from other users. This is related to a distance criterion. For urinals, for example, it is known that users prefer to leave at least one urinal between them, see (Kranakis E., Krizanc D. (2010) The Urinal Problem. doi:10.1007/978-3-642-13122-6_28), below (Kranakis and Krizanc). If this is done uncontrolled, it quickly leads to two-unit "gaps" between users. This is often undesirable, as it causes incomplete utilization of system capacity, i.e. performance below maximum capacity. For example, consider a row of five sequentially numbered units (see also, e.g., Example 3). If a first and second user occupy the first and fourth positions (number 1 and 4), then a third user must necessarily wait or take up one of the units immediately adjacent to the occupied units. However, the latter is less likely to even unlikely in the case of urinals, see (Kranakis and Krizanc), so the third user will resort to a stall. This has the disadvantage that the total capacity of the toilet facilities is used up too quickly. This becomes even more detrimental if the toilet facilities also have gender-neutral stalls. In such a case, a user (male) will, instead of occupying a urinal, occupy a stall that is available to everyone, which is disadvantageous, because the toilet facilities thus becomes even scarcer for women than for men than it already is, see (Van Hautegem, K.,

Rogiest, W. (2017), No more queueing at the ladies' room, http://peopleqm.blogspot.com/2017/07/no-more-queueing-at-ladies-room.html), further on (Van Hautegem and Rogiest). As a result, the random behavior of male users thus creates additional congestion for *all* users, not just the men, and an incomplete utilization of system capacity. The invention solves this by either, in implementations without so-called *turnaround*, allocating to units numbered 1, 3 and 5, or, in implementations with so-called *turnaround*, ensuring that at high load all allocation is done to number 1, 3 and 5. This relates to the advantages of aligning to the maximum grid, also called "snap" or "SNP", which leads to maximum use of capacity with consideration of distance, as explained elsewhere in this document. In both cases, with or without turnaround, the control of accessibility can be purely sequential (first only first, then only next,...) or at least partially parallel, or purely parallel (at a given time all three available). For example, in examples with purely sequential allocation and no turnaround, it is advantageous to allocate first to the middle unit (number 3)and only then to the distal ones(numbers 1 and 5), because of advantages related to sequence (English: sequence), also called "SEQ", such as longer *uptime*, as explained elsewhere in this document. The units may be urinals but it is clear that the preference to keep distance may occur for all services with compartmentalized service units, e.g., sinks and stalls. This preference may also occur for very different examples, e.g., car parking spaces, where some users like to have a parking space without neighbors so that passengers easily can swing open the doors.

There are several other examples where the invention leads to a lower operational cost than with random user behavior, by optimally taking into account a distance criterion. For example, there is the advantage of longer *uptime* in the so-called sweep, also known as "SWP", which can be applied in all embodiments with two or more service units. In the case of a row of two units (number 1 and 2), according to embodiments of the invention, these are made alternately active with SWP, e.g., alternately from user to user. This is advantageous because in practice a part of the breakdowns builds up cumulatively, i.e., is not instantaneously caused by a particular user. As this part increases, sweeping can significantly increase the *uptime* of both units, and increase the average time until first breakdown, for example, by at least 10%, preferably by at least 20%. This is relative to the situation with random user behavior, where, in the case of urinals for example, typically the same "furthest" urinal is always chosen, see (Kranakis and Krizanc). This is not only the case for a row of contiguous units, where keeping distance may play a dominant role, but also for two units standing far apart, where each time the first user arriving in an empty system may be alternately referred to one, and then to the other unit. This applies to all forms of service units, e.g., urinals or stalls.

There are still other examples where the invention leads to a lower operational cost are related to *turnaround*, below also "shake" or "SHK", in particular examples with at least one odd row of units with length at least three. This is another way of taking into account a distance criterion. This is related to embodiments where control aims to achieve allocation to a maximum grid when workload increases or remains high and/or where control aims to achieve allocation to a minimum grid when workload decreases or remains low. For example, in examples with a row of three incrementally numbered units it is advantageous to refer each time the first user arriving in an empty system to the

second unit (number 2), and then serve new users who would arrive before the user's departure with the maximum grid (numbers 1 and 3). This way, the units of the maximum grid are maximally saved, with maximization of the uptime of the maximum grid. On average, this entails some additional waiting time for said new users, because the switch from minimum grid to maximum grid in a row of three can only happen when the first user leaves. But this waiting time is small and is also even lower the longer rows are. For longer rows, e.g. rows of seven units, after the first user is assigned to a unit of the minimum grid, e.g. number 2, the turnaround does not have to wait. New users can be assigned numbers 5 and 7. In most cases, number 2 has become free in the meantime, after which numbers 1 and 3 can also be assigned, without a delay.

Still other examples where the invention leads to a lower operational cost relate to sequence, also "sequence" or "SEQ". This is another way of taking into account a distance criterion. In preferred embodiments, access is arranged so that redundant units (i.e., pairs of units where the breakdown of a unit does not reduce the maximum capacity) are assigned first to first users each time. In preferred implementations, in the absence of redundant units, allocation is made to medial units (i.e., non-distal units) rather than to distal units (i.e., units located at one end of a row). In preferred embodiments, assignment to a distal unit (i.e., unit located at extreme of a row) occurs with lower preference than an assignment to a medial unit, which in turn occurs with lower preference than an assignment to a redundant unit. For example, in an ascending row of length five, it may be advantageous in embodiments to choose number 2, 3, or 4 earlier than 1 or 5. This is because in the event of breakdown of number 2 or 4, there is a lower operational cost than in the event of breakdown of a unit of the maximum grid, such as 1 or 5. But also a breakdown of number 3 is more advantageous than a breakdown of 1 or 5. After all, a breakdown of number 3 leads to two rows of length two, which are mutually redundant two by two, i.e. if one of each pair fails, there is still a maximum capacity of two units. Breakdown of number 3 thus leads to higher robustness than a breakdown of number 1 or 5. A breakdown of number 1 or 5 leads to a row of length four, which is less robust to further breakdowns than two rows of length two, see also example elsewhere in this document.

In conclusion, the method according to the invention enables any strategy consisting of SWP and/or SEQ and/or SNP and/or SHK, each of which can reduce the operational cost of compartmentalized service units. These strategies optimally take into account a distance criterion, which may be explicit, as in measures related to social distancing, but is at least in part implicit, as random human behavior may include a form of keeping distance. Further, the method according to the invention also allows for strategies with partial accessibility, with or without a distance criterion, with advantages as explained later herein. The partial accessibility strategies can be combined without limitation with (or without) SWP and/or SEQ and/or SNP and/or SHK, and all combinations are therefore considered to be described herein.

In a second aspect, the invention provides a device for controlling an accessibility with respect to a plurality of compartmentalized service units (1a-1e), said device comprising:

- a service unit;
- a sensor;
- means of switching the accessibility of a service unit;

wherein said device is configured to perform the steps of:

- monitoring, using said sensor, a state of use of a first of said service units;
- upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa; generating, by means of said service unit, a signal indicative of said change;
- upon detection of said signal, by said means of switching the accessibility, switching the accessibility, of a second of said service units different from said first service unit;

whereby said switching of accessibility of the second service unit occurs between at least two of a plurality of accessibility modes including at least two of "fully accessible", "conditionally accessible", and "inaccessible".

Such a device can be advantageous because it allows the method of operation to be implemented, because it can be produced in a compact and inexpensive manner and can be installed quickly. In embodiments, the design is very simple, wherein said sensor is related to a motion sensor or a door sensor mounted on a door and/or in the vicinity of said first service unit, and wherein said means includes a visual indicator, preferably a screen or a colored light source such as a green or red LED, and/or wherein said means includes a door lock/unlock of a door of said second service unit.

In a third aspect, the invention provides a use of a plurality of devices, wherein said devices are arranged in series such that a first device based on monitoring of a first service unit controls the accessibility of a second service unit, a second device based on monitoring of at least the second service unit controls the accessibility of a third service unit, and so on.

Such use can be advantageous because it can simplify the installation. In embodiments, each subsequent device performs monitoring of all previous or adjacent service units, but embodiments with only monitoring of only the adjacent service unit are also effective. The advantage of such use is that it is particularly suitable for making rows of service units, for example toilet stalls, conditionally accessible during periods of low workload, and gradually making the stalls unconditionally accessible one by one as workload increases. Examples involve toilet facilities where one gender-neutral toilet is available, followed by a row of switchable toilets accessible only to women, and, for example, one more toilet permanently accessible only to women, all unoccupied. Once the gender-neutral toilet is in use, the next toilet accessible only to women becomes unconditionally accessible. If this also becomes occupied, the next toilet only accessible for women also becomes unconditionally accessible, i.e. it becomes a gender neutral toilet. The advantage here can be that at low workloads for women, a large reserved row of toilets is provided, and effective triage takes place. The triage

can ensure that men primarily head towards the permanent gender-neutral toilet, whether or not supplemented by a permanent toilet accessible only to men, while women can head towards the permanent women's toilet. This can lead to an advantageous distribution of the flow of users throughout the building. In embodiments, this can at the same time allow for at least one toilet to be available that is accessible to everyone at all times, as long as supplies of switchable toilets last. Such arrangements are not known in the state of the art and thus provide both the benefits of triage and the avoidance of queues due to static accessibility. In embodiments, when the toilets are released again, the switchback can proceed neatly from right to left if each subsequent device does the monitoring of all previous service units, but the switchback is also possible for embodiments with only monitoring of only the adjacent service unit.

In a fourth aspect, the invention provides a system for controlling an accessibility with respect to a plurality of compartmentalized service units related to toilet facilities, said device comprising:

- a service unit;
- a plurality of sensors, one per service unit;
- means of switching the accessibility of each of the service units;

wherein said device is configured to perform the steps of:

- monitoring, using said plurality of sensors, a state of use of each of said service units;
- upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa of at least one service unit, calculating, by the service unit, whether a switch of accessibility of at least one service unit is desirable, preferably based on a predetermined switch pattern;
- if a switch is desired, the generation, by means of said service unit, of a signal indicative of said change;
- upon detection of said signal, switching, by said means of switching the accessibility, the accessibility with respect to the at least one service unit for which switching is desired;

wherein said switching of accessibility of the at least one service unit occurs between at least two of a plurality of accessibility modes comprising at least two of "fully accessible", "conditionally accessible", and "inaccessible".

Such a system may be advantageous because it may be particularly suitable for making rows of service units, for example toilet stalls, accessible according to a changeover pattern, where it may be advantageous to control the accessibility of all service units simultaneously.

Moreover, in embodiments of the system, the design is very simple, wherein said sensors are related to a motion sensor or a door sensor mounted on a door of and/or in the vicinity of the service units and wherein said means comprise a visual indicator, preferably a screen or a colored light source such as a green or red LED, at the height of the respective service unit and/or wherein said means comprise a door lock/unlock of a door of the respective service unit.

Further embodiments and their respective advantages are described in the detailed description and dependent claims.

Description of figures

Figure 1a shows an example layout of five aligned compartmentalized service units (1a-1e) according to an example embodiment of the invention.

Figure 1b shows an example layout of seven aligned compartmentalized service units (1a-1g) according to an example embodiment of the invention.

Figure 1c shows an example layout of three aligned compartmentalized service units (1a-1c) according to an example embodiment of the invention.

Figure 1d shows an example layout of six aligned compartmentalized service units (1a-1f) according to an example embodiment of the invention.

Detailed description

In this document, "compartmentalized service unit" refers to an area located in space that is associated with a functionality to control a user. Examples of service units are toilet units such as stalls, urinals or sinks. Still other examples are fitting rooms, such as those in clothing stores, or locker rooms, such as those in swimming pools, gymnasiums, saunas, and professional environments. Still other examples are shower stalls, such as those found in swimming pools, gymnasiums, saunas, and professional settings. Still examples are seats in waiting rooms or galleries. Still other examples are parking spaces. In this document at least two service units are always considered, which are located in some proximity to each other. In embodiments, the first and second service units are located in the same building, on the same business park, on the same recreational field, in the same exhibition hall or cinema or theater, or in the same city neighborhood. In embodiments, the first and second service units are located at a distance of less than 50 meters, preferably less than 20 meters, from each other and/or in the same room. In alternative embodiments, the first and second service units are located at a distance greater than 20 meters, preferably greater than 50 meters, from each other and/or on different floors of a building and/or in different wings of a building and/or in different locations of a site or city neighborhood. In embodiments, one or more of the service units are delineated in space, as is typically the case for toilets, fitting rooms, locker rooms, and shower stalls. In embodiments, one or more of the service units are not strictly delineated in space but are still associated with a particular area, as is the case with urinals or sinks.

In this document, a "grid" refers to a subset of a set of aligned service units, or, equivalently, contiguous service units, extending between two ends or to a subset of a set of circularly arranged service units. A grid extends over the set of service units according to a given grid distance *r*, with *r* a natural number, when there is at least a distance of *r* service units between each given member of the grid and each of the other members of the grid, i.e., a distance criterion. In embodiments where

the grid is a subset of a set of aligned service units extending between two ends, all members of the set and thus all members of the grid lie on a path extending between the ends, the two members of the grid located near the ends each have one neighbor which belongs to the grid and is most closely located according to a medial direction of the path, and the other members of the grid each have a respective first and second neighbor which belongs to the grid and is most closely located according to a first and second distal direction of said path, respectively. In embodiments in which the grid is a subset of circularly arranged service units, all members of the set and therefore all members of the grid lie on a path without end, said path being a circle, and all members of the grid each have two neighbors which belong to the grid and which are most closely located according to a circumferential and an opposite circumferential direction on said path. In embodiments, a second grid is arranged staggeredly with respect to a first grid. In embodiments, a second grid is arranged staggeredly with respect to a first grid when for at least a predetermined share of the members of the second grid exactly one member of the first grid is located on the path to each of its neighbors. In preferred embodiments, said predetermined proportion is at least one-third, preferably two-fifths, more preferably one-half, even more preferably three-fifths.

In this document, "aligned grid" refers to a subset of a set of aligned service units. Here, the plurality of service units may include one or more respective sets of aligned service units, which are associated with respective service units grouped in space.

In this document, "circularly arranged grid" refers to a subset of a set of circularly arranged service units. Herein, the plurality of service units may include one or more respective sets of circularly arranged service units, which are associated with respective service units grouped in space, each of which may be aligned service units or circularly arranged service units.

In this document, "busy period" refers to a period commencing with the arrival of a user in an empty system, which extends for as long as at least one user is continuously present in the system. The "user" receives service from a service associated with a service unit, e.g., a toilet visit or a parking session. The busy period ends when the system becomes empty again. In this context, this document refers to "first users", i.e. the user who arrives in an empty system and initiates the busy cycle, and "next users", i.e. the one or more users who find the system non-empty, and correspond to the rest of the busy cycle.

In this document, the term "uptime" refers to a period for keeping a certain level of operation intact. The uptime is related to the operational cost; in preferred embodiments, allocation according to the invention is done such that a certain *uptime* is maximized. *Uptime* here is an umbrella term for various performance measures. For example, there is the "uptime at maximum capacity". This term refers to the period during which a system, with or without broken down units, can still maintain the maximum number of currently available units. Here "maximum capacity" is preferably considered taking into account a distance criterion. Thus, the maximum capacity of a row of three units taking into account a spacing of one empty space is two units. If the middle unit of the row of three fails, the maximum capacity is maintained, at three units. If one of the extreme, lateral units of the row of three fails, the

maximum capacity drops by one unit, to two units. The term "uptime of the maximum grid" is a related concept, and refers to the time that the maximum grid remains intact.

In this document, the state of a system with a single row of contiguous active (not broken down) service units of length *L*, or, equivalently, an aligned row of length *L*, is denoted as [L]. A system state with a single set of *L* circularly arranged active service units is denoted [$\underline{L}$]. A system state with *N* respective active rows $L_1, L_2, ...L_N$ of service units is denoted as [L_1,L_2,...L_N], where $L_1 \leq L_2 \leq ... \leq = L_N$. For example, the notation [4] refers to a system state a single row of four active service units. If the first or fourth service unit fails, the system state changes to [3]. On the other hand, if the second or third service unit fails, the system state changes to [1,2], i.e. one-in-a-row and two-in-a-row. Correspondingly, this notation is referred to as "in-a-row-notation".

In embodiments, a set of aligned service units consists of a row extending between two ends. In embodiments, a set of circularly arranged service units consists of a row extending according to a circle, i.e. without ends. For such sets, either aligned between ends or arranged circularly, for size $L = 2m$, with *m* a natural number, there are, for example, two equidistant grids with grid spacing 2, in short, 2-grids, both consisting of *m* service units, which are arranged staggeredly with respect to each other. Here the first grid comprising the first service unit has offset 0, and the other grid comprising the second service unit has offset 1. Analogously, for such sets, either aligned between ends or arranged circularly, for size $L = 2m+1$, there are, for example, two 2-grids, the first of which comprises $m+1$ service units (offset 0), and the second of which comprises *m* service units (offset 1), which are arranged staggeredly with respect to each other. Analogously, for such sets, either aligned between ends or arranged circularly, for size 3m, there are, for example, three equidistant grids, each with grid spacing 3, known as 3-grids, each consisting of *m* service units, which are arranged staggeredly with respect to each other, with respective offsets 0, 1, 2. Analogously, for sets with size 3m+1, or $3m+2$, respectively, there are one grid with number $m+1$ (offset 0) and two with number *m* (offsets 1 and 2), or two grids with number $m+1$ (offsets 0 and 1) and one with number *m* (offset 2), respectively. In general, for each grid spacing *r*, with *r* a natural number, there are for example *r* different *r*-grids as subsets of a set with size $r \cdot m+v$, with $0 \leq v \leq r-1$, with for the first *v* grids (offsets 0...$v-1$) as size $m+1$, and the remaining $r-v$ grids (offsets $v...r-1$) size *m*, arranged staggeredly with respect to each other, and this regardless of whether the set is aligned between ends or arranged circularly.

In embodiments, said second compartmentalized service unit is a urinal or sink, and said switching occurs only between "unrestricted access" and "inaccessible". In alternative embodiments, switching occurs between all switching modes of "unrestricted access," "restricted access," and "inaccessible."

In embodiments, the accessibility of the service units is controlled by means of light elements, one per unit, which are preferably located at the level of the respective service units. If the color is red, this means that the unit cannot be used, i.e. it is inaccessible. If it is green, this means that the unit is available, i.e. "fully accessible". In example implementations a third color is defined, e.g., blue, when it is detected that the unit is in use. Such a color scheme, with, e.g., only three colors, is very

advantageous when controlling access to urinals, parking lots, or stalls for which "conditionally accessible" is not defined, such as gender-neutral stalls. In implementations with "conditionally accessible" the conditional accessibility can be indicated with a color scheme but also with, e.g., pictograms, such as the well-known m/f pictograms for men and women, or, more recently, the m/f/ pictograms, to toilets as known to the skilled person.

In embodiments light elements are controlled by means of a service unit which is connected to a detection unit or sensor. The detection unit at least detects movement, and is thus able to detect the state of use ("not in use" or "in use") of each of the units. In example embodiments, each unit has a separate sensor.

In this document, "control of accessibility" is an umbrella term encompassing access control, as known to the skilled person. Access control traditionally means the process of granting or not granting access, with the goal of answering and effectuating the question "does person X have access to facility Y". This can relate to interaction between the system and the person, for example, based on lock and key, based on biometrics, challenge response algorithms, and cryptographic keys, whether or not in the form of an RFID badge or a machine-readable tag, such as a 2D barcode, for example, a QR code. Traditionally, the set of people who have access is a fixed given that is tied to an identifier such as a personal ID or group ID, which, while customizable in a system by an operator, is not intended to vary dynamically without operator intervention. "Control of accessibility" is understood more broadly in this document, where the set of individuals in embodiments varies dynamically according to the state of the system. In embodiments, no identification is provided at the level of individuals. Rather, access is either unconditional, impossible, or dependent on a condition associated with a triage parameter. This triage parameter is aimed at distributing the workload among different service units.

In methods and systems according to embodiments, it is advantageous that access occurs according to a form of triage, because in this way access flows are spread throughout a building. In this way the access routes to the service units and the actual access to the service units are less loaded, and/or the workload is better distributed over the various service units or groups of service units, disparate or not, and/or it becomes easier for users to respect the necessary mutual distance according to a distance criterion, e.g., a distance criterion according to random behavior, and/or a social distancing distance, on the way to and from the service units.

A further advantage of accessibility control according to the invention is the dynamic nature of accessibility, which leads to a more efficient use of service units than static accessibility.

- First of all, dynamic accessibility allows the inefficiency inherent in static conditional accessibility to be greatly reduced. After all, the familiar form of conditional accessibility based on gender (male/female), according to the state of the art, leads to queues at the level of service units of one of the two genders, such as the well-known example of queues at the level of the women's toilet, while the other gender's toilets are still unoccupied. However, conditional accessibility can be

useful, but only becomes efficient if it is dynamic. Conditional accessibility here provides the benefits of triage, based on a triage parameter, which allows access flows to be spread across a building, as described in this document. The dynamic character, on the other hand, where for example conditional accessibility is switched to full accessibility, prevents the occurrence of long queues, such as the well-known queues at the women's toilet, by dynamically switching from a men's toilet, i.e. a conditionally accessible toilet, to an unconditionally accessible toilet, i.e. an "any gender" toilet. Hereby, it is free to provide, in addition to the aforementioned first and second service units, for example, further service units that are permanently unconditionally accessible, such as gender-neutral toilets, or service units that are permanently conditionally accessible, or toilets accessible only to women. Urinals, which apart from conditional access are in practice only accessible to men, can also be added for example. The same applies furthermore to the first service unit, which, although monitored, can have switchable or non-switchable access in embodiments. As long as the share of switchable service units, including the second service unit, is sufficiently large, they allow queues to be drastically reduced.

– Second, dynamic accessibility allows to reduce the operational cost of service units, by ordering successive services. This ordering allows to reduce the operational cost associated with the random behavior of users. Related to this, this additionally or alternatively allows to efficiently deal with requirements related to social distancing and/or other measures for preventing the spread of infectious diseases at the level of service units. Such requirements lead, for example, to the need to leave one service unit empty each time between two occupied service units. Thus, in examples, one stall must be left between, or two urinals must be left between, in order to respect social distancing. According to the state of the art, this problem can be solved by selectively, according to a grid, making service units statically inaccessible. However, this leads to inefficiency, since such a way of working is not robust with respect to a breakdown of an accessible service unit. Also according to the prior art, it can be left to the users to keep distance, but this leads to inefficiency because in case of high workload, i.e. not empty queue, it is not guaranteed that the maximum grid, i.e. the grid with largest number of service units, is effectively available. The invention allows service to be organized so that at high workloads the maximum grid is offered to users, and, according to various embodiments, preferably the minimum grid (if any) when the workload is low.

In embodiments where conditional accessibility is provided, the invention allows to greatly reduce the inefficiencies inherent in static conditional accessibility, while efficiently dealing with a distance criterion, e.g., requirements related to social distancing and/or other measures for preventing the spread of infectious diseases at the level of service units.

In preferred implementations, said "conditionally accessible" is related to a triage parameter which aims at distributing the workload among different service units. This is advantageous because it allows access flows to be spread across a building, leading to better ordering. It allows access routes to the service units and the actual access to the service units to be less loaded, and/or the workload

to be better distributed over the various service units or groups of service units, whether or not disparate groups of service units are spread over the building, and/or it makes it easier for users to respect the necessary mutual distance according to a distance criterion, e.g. a distance criterion according to random behavior and/or a social distancing distance, on the way to and from the service units.

In embodiments, said detection is related to the change from said "not in use" to said "in use", and wherein said switching of accessibility happens from said "conditionally accessible" to "fully accessible".

In embodiments, the triage parameter is at least partially based on a predetermined system parameter.

In example embodiments, the triage parameter is at least partially based on a predetermined parameter being an attribute of an access ticket of an event taking place in the building to which the service units belong, such as the seat number or the building zone to which the user has access by means of the ticket. The latter corresponds, for example, to a triage in practice, whereby toilets are accessible according to the access zone of the visitor's ticket, e.g. "green zone only" or "blue zone only", or the seat row of the seat, e.g. being even or odd. In embodiments, it is thereby desirable that the accessibility of stalls for users of the blue zone also become accessible to users of the green zone, preferably become unconditionally accessible, if all stalls for the green zone are occupied and there are still stalls for the blue zone unoccupied. Indeed, the preferred goal of triage is to improve workload distribution without leading to additional waiting times. This can be described as "soft" triage, i.e. triage that applies only if there is still capacity available for each subpopulation, and that is "relaxed" if the capacity for one of the subpopulations proves insufficient.

In example embodiments, the triage parameter is at least partially based on a predetermined parameter being a user feature. In embodiments, this is a technical user feature (or, equivalently, conceptual user feature), such as the name of the user, e.g., a first letter of the first name or last name of the user, whereby triaging is performed according to, for example, the intervals A-M (example subpopulation 1) and N-Z (example subpopulation 2). Further examples of technical user features are the being even or odd of an identity card number. In embodiments, this involves a biological user feature, such as triage based on age and/or gender, whether or not according to intervals of age, whether or not according to labels "accessible to women" or "accessible to men." Possible advantages of such triage is simplicity for the user and/or familiarity, particularly the high familiarity of triage based on gender, and/or medical considerations related to hypotheses about preventing the spread of infectious diseases.

In embodiments, the method includes the further steps:

- providing a kiosk to a user;

- generating, by means of the kiosk, at the request of the user, and based on at least said monitored states of use, a triage parameter applicable to the said user;

- disclosing the triage parameter to the user, preferably displaying said triage parameter to the user.

In embodiments, the kiosk is a physical electronic device which is set up in the building in which the service units are located. In embodiments, this device has a touch screen and is in communication with a service unit for controlling accessibility, such as a back-end server. In embodiments, the kiosk includes a camera or scanner for recording a code on a paper or electronic access ticket, e.g., a QR code on the access ticket. In embodiments, the kiosk includes a processor which executes a kiosk application. In embodiments, the kiosk comprises only the kiosk application, such as an application on a user's smartphone. In embodiments, the kiosk application has access to real-time monitoring of the service units in the building, and, upon request from the user, it calculates a triage parameter which is then linked to the user, for example via the access ticket. This allows the workload to be spread maximally over the building's service units, by directing the user to service units or groups of service units where the waiting time is limited or non-existent. In embodiments, the calculation takes into account not only the monitored states of use, but also a distance criterion, e.g., a distance between the user or kiosk and the service units to be assigned and/or a distance between the seat or standing place associated with the access ticket and the service units to be assigned. In embodiments, the method includes the further step of verifying at the level of the assigned service units that the triage has been respected and/or making access to the service units conditional on this verification. Such verification is done in exemplary embodiments by scanning or photographing the access ticket, whether electronic or not, which was previously already linked to the generated triage parameter.

According to a further aspect, which is not intended to limit the invention, the invention provides a method for providing a triage parameter to a user, comprising the steps of

- monitoring a state of use of a plurality of service units in a building;

- providing a kiosk to a user;

- generating, through the kiosk, at the request of the user, and based on at least said monitored states of use, a triage parameter applicable to the said user;

- making known the triage parameter to the user, preferably displaying said triage parameter to the user, which is associated with a group of service units in the building.

In a further aspect, the invention provides a kiosk configured to perform such a method, as well as a system comprising one or more kiosks and a back-end server to perform such a method.

In embodiments, the method includes the further step:

- upon detection of said signal, switching the accessibility of the first of said service units between at least two of said plurality of accessibility modes.

In embodiments, the plurality of compartmentalized service units comprises a set which comprises at least a first grid and a second grid both of which extend according to a grid spacing r and which are arranged mutually staggeredly, wherein the first service unit belongs to the first grid and the second service unit belongs to the second grid, wherein said detection relates to the change from said "in use" to said "not in use", and wherein said switching of accessibility of the second service unit occurs from said "inaccessible" to "conditionally accessible" or "fully accessible".

Example 1

Figure 1a shows a first example layout, i.e. a ground plan, of five aligned compartmentalized service units (1a-1e), with a width direction according to the x-direction, and a depth direction according to the y-direction. Figure 1b shows the same, but with seven aligned compartmentalized service units (1a-1g) instead of five. Below, Figure 1a is discussed first. For Figure 1b, everything applies mutatis mutandis, except for what is explicitly discussed below.

In this example, strictly defined areas may be considered, with three walls and an entrance according to the y-direction, as in toilets (1a-1e) with a door at the level of the entrance (not shown), for example each with width r, or fitting rooms (1a-1e) with a door or curtain at the level of the entrance, for example each with width r. In another example, toilets (1a-1c) are considered with width r_1 and toilets (1d-1e) with width r_2. In examples, width r_1 corresponds to a standard width, and width r_2 is larger, for example, because (1d,1e) are family facilities or facilities accessible to wheelchair users. These may also be purely indicative boundaries, which are only partially or not delineated in the space, as in the case of wall-mounted or free-standing sinks (1a-1e), or urinals (1a-1e), whether or not separated by vertical partitions. This may also be a mixture of the foregoing, with, for example, three urinals (1a-1c), a sink (1d) and a toilet stall (1e), respectively, with three different respective widths, as found, for example, in men's toilets.

In exemplary embodiments of the invention, the invention involves five toilet stalls (1a-1e), each with width r, and the accessibility of the toilet stalls is automatically controlled by a method according to the invention. The accessibility control may be related to the locking of non-accessible toilet stalls and the unlocking of accessible toilet stalls. This is preferably visible to users, for example with a color code (red locked, green unlocked). The control of accessibility may additionally or alternatively be related to the display of an indication to the user about the accessibility of the respective stalls, for example with a screen on each door, preferably an LED screen or e-ink based screen.

Accessibility is controlled such that a distance criterion related to a predetermined minimum distance r_0, for example a social distancing distance, is respected between users. In embodiments, the walls of the stall do not extend all the way to the bottom and/or top, with, for example, a strip without wall at the bottom of 5 cm or 10 cm. Due to this, a passage for air is present between neighboring toilet stalls, which is relevant when considering social distancing. In examples, r *is* greater than $r_0/2$, which

means that people cannot maintain sufficient distance from their neighbors when entering the toilet and/or using the toilet. In examples, *r is* greater than r_0 and less than $2r_0$, making it impossible to maintain sufficient distance from immediate neighbors, but making it possible to respect that distance by each time leaving at least one stall in between with respect to neighbors, as distance criterion.

In this example, we assume a situation where *r* is greater than r_0 and less than $2r_0$, and all stalls are equal in size. This leads first to a very simple strategy, say prior art strategy A, with an easy-to-use behavioral rule (or distance criterion) "leave at least one stall between", and nothing else. Merely falling back on that behavioral rule is inefficient. This can be understood by using an example. Suppose a first user arrives to find all stalls empty, and that this user occupies stall 1a. Upon arrival of a second user, stall 1a is still occupied, and this user, because he leaves at least one stall in between, has a choice of stalls (1c-1e), and choose for example stall. A third user, upon arrival, finds stalls 1a and 1d occupied, and cannot use stalls 1b, 1c, or 1e because they do not meet a distance criterion, e.g., the social distancing distance, and therefore must wait. Strategy A is therefore inefficient for this reason. Indeed, it is more optimal to spread the users maximally across the stalls, according to an SNP strategy with respect to the maximum grid, which in this example leads to occupying three different stalls simultaneously, with the maximum grid consisting of stalls 1a, 1c, and 1e. This maximum grid is indeed occasionally realized in strategy A, but this happens only by chance, according to the twist of fate. It can just as well happen that users occupy stalls 1a and 1d, leaving an opening of two empty stalls (1b, 1c), with at most only stalls 1a and 1d in use, leading to suboptimal use of available capacity.

An alternative strategy, say prior art strategy B, consists of simply locking stalls 1b and 1d permanently, and opening only stalls 1a, 1c, and 1e to users. Such a solution guarantees maximum spread at any time. This strategy does follow an SNP strategy but is far from optimal, as it leaves stalls 1b and 1d permanently unused. This has two disadvantages.

A first disadvantage of strategy B is the additional load on the stalls that are still open. After all, there are fewer stalls to process the total user flow, with a certain arrival intensity lambda1, expressed in number per time unit. Each of the stalls 1a, 1c and 1e must therefore process one third of the user flow, whereas if all five stalls were used this would only be one fifth. This therefore leads to a relative increase in usage of 2/3, i.e. from 20% of the user flow to 33.3% of the user flow. Such an increased intensity leads to faster soiling of each stall, and also a higher probability that, for a given cleaning cycle with a frequency of, say, 2 times per day, one of the stalls becomes unusable, for example due to a blockage that can only be resolved according to the cleaning cycle. If clogging is a random quantity independent of use to use, and identically distributed among users, with probability $p1$ = 0.005 of clogging a stall in the time between two cleanings and, for example, a reference number of 30 users, then the probability of no clogging occurring is $(1\text{-}p1)^{30}$ = 86%. If the number of users increases by 2/3rds, i.e. from 30 to 50 users, then this probability shrinks to $(1\text{-}p1)^{50}$ = 78%. In other words, the probability of at least one breakdown occurring in the time between two cleanings has increased from 14% to 22%, i.e., an increase of more than half.

A second disadvantage of strategy B is the increased sensitivity to breakdowns. When a stall becomes temporarily unusable, for example as a result of a blockage, the number of stalls that can be used simultaneously falls back to a maximum of 2. This leads on average to larger queues than, for example, with strategy A, which is less sensitive to such breakdowns. When one of the extreme (1a, 1e) or the middle stall 1c breaks down, the maximum number of stalls that can be used simultaneously in that case is the same as for strategy B, namely 2. But if the breakdown occurs at stall 1b or stall 1d, then there is still a maximum simultaneous use of 3 stalls possible, which thus makes strategy A more robust to breakdowns than strategy B.

Finally, for strategy B, it should be noted that the two disadvantages are not independent but reinforce each other. Thus, the trade-off of strategy A versus strategy B is not straightforward, but rather a trade-off, where the exact value of p1 *and* lambda1 together play a crucial role. If p1 is small, with low probability of breakdown, and/or lambda1 is low, then it is to be expected that strategy B will lead to the shortest queues, as it provides maximum spreading over essentially reliable service units, with not too heavy a load on the stalls that are still accessible. If p1 is large, with high probability of breakdowns, and/or lambda1 is high, then strategy A is expected to lead to shortest queues, because it handles breakdowns better, by making better use of the remaining, not-broken-down service units.

Example strategies aimed at keeping the stalls in use

With example strategies according to the present invention, an improvement over strategy A and strategy B is possible because it combines the advantages of both.

The example strategies aim to ensure that all the stalls remain in use. In this example, with grid number equal to 2 and number of stalls equal to 5, there is one maximum grid, specifically the one with stalls 1a, 1c and 1d. This grid serves to accommodate peaks in arrival intensity. The other stalls, 1b and 1d, belong to the minimum grid, which serves to be used as much as possible in the quiet periods, so as not to unnecessarily burden the stalls of the maximum grid. Indeed, breakdowns in any of the minimum grid stalls have less effect on system performance because they are not accessible at the time when the waiting time builds up the most, i.e., at high arrival intensity.

The example strategies are characterized by allocation to the minimum grid, at low load, and allocations to the maximum grid, at high load. In between, a grid switchover, or, equivalently, grid turnaround, turnaround for short, happens each time. This turnaround is easiest to understand through examples. The example strategies each time assign a stall of the minimum grid to a first user (or, equivalent, visitor) who arrives in an empty system. If this first user leaves without anyone having arrived, the next, second user is again assigned a stall of the minimal grid, for example, the other of the two, or a random choice from one of the two stalls of the minimal grid. An advantage of choosing the other stall is that there is additional time for possible cleaning by an operator of the used stall, and/or more air exchange can take place in the stall that has just been used, which lowers the chance of contamination of the second user by the first user.

If the second user arrives before the first user has left, there are again several variants of example strategies. First, there are variants with early turnaround, where the priority is to keep the waiting time as low as possible. In this case a stall of the maximum grid is made available. This is always possible while respecting the minimum distance: if the first user received stall 1b then this stall is 1e; if the first user received stall 1d then this stall is 1a. Second, there are variants with late turnaround, where the priority is to keep the maximum grid free from breakdowns for as long as possible by using it as little as possible. In doing so, the other stall of the minimal grid is also made accessible. Now, if there is a peak in arrival intensity, with a large group of users, including a third and fourth user, arriving while the first and second users are still present, for example in stalls 1b and 1e, then according to both the first and second variants, these users must wait for a while. As soon as either user leaves, no matter which one, then the third user can occupy a stall. In variants with early turnaround where the stall of the minimum grid becomes free, for example stall 1b of stalls 1b and 1e, only the stall of the maximum grid remains occupied, in the example stall 1e, and the system permanently switches to allocation according to the maximum grid, serving three users in parallel. So both the third and fourth user get access immediately, in the example this is access to stalls 1a and 1c. And the complete peak can thus be absorbed according to the maximum grid (1a, 1c, 1e). This corresponds to the earliest possible turnaround. In variants with early turnaround where the stall of the maximum grid becomes available first, in the example stall 1e of stalls 1b and 1e, the released stall 1e is immediately made accessible again, in order to continue occupying already filled stalls of the maximum grid. The third user thus gets a stall of the maximum grid. Only when the stall of the minimum grid becomes free, in the example stall 1b, there is only a stall of the maximum grid occupied, in the example stall 1e, and the rest of the peak is absorbed exclusively with stalls of the maximum grid, i.e. with the service of three users in parallel. In variants with late turnaround, stalls 1b and 1d are occupied, and the first one that becomes free is replaced by a stall of the maximum grid (1a, 1c, 1e). This is always possible: when 1b is freed it is 1e, when 1d is freed, it is 1a. Then a strategy similar to the early turnaround follows: the stall of the maximum grid is maintained, and the stall of the minimum grid is exchanged for the remaining two stalls of the maximum grid as soon as it is abandoned. The remainder of the peak is again absorbed with the maximum grid.

When the peak in arrival intensity is followed by a more quiet period, in principle the opposite happens, provided that it is now the early turnaround that corresponds to variants where the priority is to keep the maximum grid free of breakdowns for as long as possible, and the late turnaround that corresponds to variants where the priority is to keep the waiting time as low as possible. For example, the situation may arise where stall 1c and stall 1e have already become vacant, but stall 1a is still occupied. When a user arrives, he or she will be allocated a stall 1d at early turnaround, and at late turnaround he or she will still be allocated a stall from the maximum grid, i.e. either stall 1c or stall 1e.

The above is true for the layout of Fig. 1a, and can be generalized to any layout with L = 2m+1 stalls, with m a natural number greater than 1. For Fig. 1b, with m equal to 3, corresponding to 7 stalls, the maximum grid has four stalls (1a, 1c, 1e, 1g) and the minimum grid has three stalls (1b, 1d, 1f).

Again, the minimum grid is what is used at low load, and the maximum grid is what is used at high load. The main difference is that now there is not just an early and late turnaround, but rather different "speeds." For example, one can switch as soon as one stall of the minimum grid is occupied, for example stall 1b. This then corresponds to the earliest turnaround. This has the advantage that, with increasing traffic, only stalls of the maximum grid can be allocated, in the example stalls 1e and 1g, and that two more allocations can be made at the same time before the freeing of the occupied stall of the minimum grid "becomes urgent". Only when a next user arrives and, in the example, the stall 1b is still not released by the first user, and the stalls 1e and 1g are still occupied, whether after switches or not, then the user must wait while less than four stalls are occupied. This means that the so-called switchover waiting time is not zero. In most cases, however, the switchover waiting time is zero, and users only have to wait when four stalls are already in use. The occurrence of a switchover waiting time is only present in this example, and only occurs in cases where the number of not-broken-down stalls is odd (see also below).

For Fig. 1c, with *m* equal to 1, corresponding to 3 stalls, the maximum grid has two stalls (1a, 1c) and the minimum grid has one stall 1b. In preferred embodiments, which are especially advantageous with such a low number, accessibility is handled as follows. The minimum grid in this example is what is *initially* used at low load. As long as it is occupied, no one can use stalls 1a and 1c. As soon as it becomes free, stall 1b becomes inaccessible and stalls 1a and 1c become accessible. In other words, this corresponds to the turnaround. If one or more users were already waiting at that time, the switchover waiting time is different from zero; if not, the switchover waiting time is zero.

- In preferred embodiments, only a predetermined amount of time is available to occupy at least one of the stalls (1a, 1c) of the maximum grid. This time, the *occupation time*, is, for example, 30 seconds or 1 minute. If none of the stalls (1a, 1c) are occupied during the occupation time, then accessibility switches back, and only the one stall 1b of the minimum grid becomes accessible, and stalls 1a, 1c of the maximum grid become inaccessible again. In this way, the switching waiting time is kept as low as possible, but the one stall 1b of the minimal grid is still used as much as possible, so that the stalls of the maximum grid remain available for the moments when they are really needed, i.e. at high load.
- In yet other embodiments, the stalls (1a, 1c) remain accessible as usual. Only when one or both of the stalls are taken, and the system is left empty again, the accessibility switches back to the minimal grid. This has the advantage of applying a more predictable pattern of accessibility, which can be more user-friendly.

Whereas the above arrangements of Figs. 1a-c apply to an odd number of stalls, i.e. L = 2m+1 stalls, Fig. 1d shows a layout with an even number of stalls $L = 2m$, here with m=3, and a total of six stalls. In this case, there is no minimum grid, and there are just two maximum grids: a first maximum grid of three stalls (1a, 1c, 1e) and a second maximum grid of also three stalls (1b, 1d, 1f). Unlike for odd numbers, for even numbers there is no a priori preference (or *bias*) for a low load grid and a high

load grid. However, there is again the preference for having a turnaround take place regularly, from the first to the second maximum grid, and vice versa. Indeed, this has the advantage that any soiling is spread across all stalls, and also that the risk that, for a given cleaning cycle at a frequency of, say, 2 times per day, one of the stalls becomes unusable, is spread across all stalls, rather than across one of both grids, as would be the case with strategy B.

Whereas arrangements with even number of stalls do not show an a priori preference (or *bias*) for a low load grid and a high load grid, in preferred embodiments the opposite is true *a posteriori*, i.e., as soon as it is detected that one of the stalls (1a-f) has become unusable. As soon as a breakdown is detected, for example because a stall remains unused for a long time, for example stall 1b, although the other stalls of the grid remain in use, for example stalls (1a, 1c-f), then the grid to which the broken-down stall belongs no longer is a maximum but a minimum grid, with for example only stalls (1d, 1f) operational. In this case, the system does assume an a posteriori bias: from then on, the total number of stalls becomes odd, L = 2m-1, and is allocated as in the case of an odd number of stalls. Thereby the "reduced" grid, e.g., consisting of stalls (1d, 1f), now becomes a minimum grid used at low load, and the "intact" grid, e.g., consisting of stalls (1a, 1c, 1e), becomes the only remaining maximum grid, then used at high load.

In preferred embodiments, this reasoning continues for layouts with an even number of stalls $L = 2m$ and other values of m. In each case, there is no *bias* as long as the number of operational stalls is even, but there is a regular switchover between one maximum grid and another. With a first broken-down stall, there is *bias*, and the grid that includes the broken-down stall becomes the minimum grid used at low load, and the other grid becomes the maximum grid used at high load.

In preferred embodiments, this similar reasoning applies equally or alternatively to layouts with odd number of stalls. As long as all the stalls are operational, there is a *bias* where the minimum grid is employed at low load and the maximum grid is employed at high load.

- If it is detected that a stall of the maximum grid has broken down, then both grids count the same number of stalls, and the system becomes one without bias, with two maximum grids, providing a regular changeover (or, equivalently, grid switching) between the two maximum grids.
- If it is detected that a stall of the minimum grid has broken down, then there is a difference of two stalls between the minimum grid and the maximum grid. In embodiments, this leads to a conservation of bias, where the minimum grid is used at low load and the maximum grid at high load. In other embodiments, this leads to a modified bias, where there is an earlier switch to the maximum grid, even when the load is not yet so high.

For both arrangements without bias and with bias, there are variants of the switchover pattern.

In embodiments, for example for arrangements without bias, the switchover pattern is symmetrical. An example of such symmetric switchover pattern is a windshield wiper pattern, where a gap propagates from left to right and back. For example, in the example of Fig. 1d, with a first (1a, 1c,

1e) and second (1b, 1d, 1f) maximum grid, at some point there is a situation of maximum occupancy on the second maximum grid (1b, 1d, 1f). There is a gap at the edge on stall 1a: a space that is not strictly needed. When stalls 1d and 1f are released, accessibility is not switched (the same stalls remain available); when stall 1b is released, accessibility is switched: stall 1a becomes accessible and stall 1b becomes inaccessible. Thus, a first phase of switching from the second maximum grid to the first occurs. As a result, the gap 1a is shifted to stalls 1b and 1c. These create a spacing of two stalls between neighboring stalls 1a and 1d, i.e., one more stall than strictly necessary. This gap can now propagate like a windshield wiper as follows. As soon as stall 1d becomes free, stall 1c becomes accessible and stall 1d becomes inaccessible. The gap thus shifts from (1b, 1c) to (1d, 1e). This is the second phase of the turnaround. As soon as stall 1f becomes available it switches from stall 1f to stall 1e, i.e. stall 1e becomes accessible and stall 1c inaccessible. The gap shifts from (1d, 1e) to 1f. This is the final phase of the turnaround: the first maximum grid is now the active grid. From then on, the wiper makes the reverse move. At the next opportunity, i.e. when stall 1e becomes free, the gap shifts back from right to left, i.e. from 1f to (1d, 1e), and so on. In embodiments, as long as the load remains high, with at least one waiting each time a stall is released, the wiper pattern is maintained. If the load is lower, this wiper pattern can also be maintained as much as possible, although accessibility can also be controlled with a histogram-based pattern. Such a wiper pattern works optimally at high load (non-empty queue) in cases where the total number of stalls is even, $L = 2m$.

In embodiments, switching is not done at every opportunity, but only after the expiration of a predetermined delay time, or after the expiration of a predetermined delay number, i.e. a number of opportunities. This can be homogeneous delay times and/or delay numbers, but also inhomogeneous, where there are differences at the level of edges, for example. This allows to keep in use for a longer period of time the stalls that would be less addressed at the edge, in order to spread the workload as much as possible over the available stalls.

In embodiments, switching is done according to a maximum-switchover pattern, where a gap of maximum propagates back and forth. For example, in the example of Fig. 1d, with a first (1a, 1c, 1e) and second (1b, 1d, 1f) maximum grid, at some point there is a situation of maximum occupancy on the second maximum grid (1b, 1d, 1f). There is a gap at the edge on stall 1a: a space that is not strictly needed. When stalls 1d and 1f are released, accessibility is not switched (the same stalls remain available); when stall 1b is released, accessibility is switched: stall 1a becomes accessible and stall 1b inaccessible. Thus, a turnaround occurs with mixing of the second maximum grid and the first. As a result, the gap 1a is shifted to stalls 1b and 1c. These create a spacing of two stalls between neighboring stalls 1a and 1d, i.e. one stall more than strictly necessary. This gap, unlike a windshield wiper pattern, can now propagate both to the left and to the right, depending on which stall becomes available first.

In embodiments, switching is done according to a histogram-based pattern, with an individual counter of number of users per stall, where the workload is directed as much as possible to stalls with the

lowest counter. In embodiments, this histogram-based pattern is partially employed, e.g., only at low load, while at high load, for example, allocation is made according to a windshield wiper pattern or a maximum-switchover pattern.

In embodiments, a histogram-based pattern is used at least partially if the number of active (not broken down) stalls is or becomes even, $L = 2m$, and maximum use is made of the one or more minimum grids at minimum load if the number of stalls is odd, $L = 2m + 1$. In this way, maximum grids are only used when the workload is high, which is advantageous because it can reduce waiting time, and keep the maximum grids "intact", i.e. not broken down, for as long as possible.

Above, examples have been given above for r greater than r_0 and less than $2r_0$. This can easily be generalized to other minimum distances, for example, for r greater than $2r_0$ and less than $3r_0$, and $L=3m+i$, with i equal to 0, 1, or 2. For example, in embodiments with $L=3m+i$, a histogram-based pattern is used at least in part if the number of active (not broken down) stalls is or becomes a multiple of three, $L = 3m$, and the maximum use of the one or more minimum grids at minimum load is sought if the number of stalls is not a multiple of 3, $L = 3m + 1$ or $L=3m+2$. In embodiments, the allocation between these minimum grids is then again at least partially histogram-based.

In embodiments, for arbitrary value of L or r, real-time checking is performed to determine the number of maximum grids and the number of minimum grids, preferably taking into account detected breakdowns of one or more stalls.

In embodiments, if all grids are maximal, switchover patterns are used that are at least partially histogram-based.

In embodiments, if at least one grid is minimum, switchover patterns are used that assign mainly to stalls of the one or more minimum grids when the workload is low, and assign mainly to stalls of the one or more maximum grids when the workload is high.

Examples have been given above for aligned grids, but the invention equally relates to circular grids. Also for circular grids, the concepts of maximum grids, minimum grids and gaps are defined accordingly. A distinction, however, is that the presence of gaps relates differently to the total number of stalls L. In embodiments with r greater than r_0 and less than $2r_0$, there are two maximum grids when L is even, $L = 2m$, but there is no gap, and in each case for $L=2m+1$ with m greater than or equal to 2, there is a respective gap, and a respective minimum and maximum grid. Because of this difference, in embodiments when $L=2m$ is even, one of the two maximum grids can be sacrificed as a sum of minimum grid with $m-1$ stalls and a gap, preferably to be used at low workload, while the remaining grid, being a maximum grid, can be utilized at maximum workload. In embodiments where $L=2m+1$ is odd, a gap is automatically present, and there are two maximum grids, and the allocation can be, for example, histogram-based. In embodiments with circular grid, a windshield wiper pattern is still possible for propagation of the gap, apart from to the additional possibilities of a continuous propagation in clockwise direction or a continuous propagation in counterclockwise direction. A maximum-switchover pattern is also equally conceivable for propagation of the gap. In

implementations with r greater than $2r_0$, the invention is equally applicable. For example, with r greater than $2r_0$ and less than $3r_0$, embodiments with $L=3m$ count three maximum grids, wherein one of the three maximum grids can be sacrificed as a sum of minimum grid with $m-1$ stalls and a gap, preferably to be used at low workload, while the remaining grids, being maximum grids, can be utilized at maximum workload, histogram-based or not. In embodiments with r greater than $2r_0$ and less than $3r_0$, embodiments with $L=3m+1$ or $L=3m+2$ count at least one gap, which can again propagate according to, for example, clockwise or counterclockwise or windshield wiper pattern or maximum-switchover pattern.

Example 2: four service units with sweep (SWP), sequence (SEQ) and snap (SNP)

In exemplary embodiments according to Example 2, the invention relates to a method for controlling an accessibility with respect to a plurality of compartmentalized service units being, for example, four urinals, which are arranged in a row. The row of urinals extends between a first end and a second end, with respective references 1a, 1b, 1c and 1d (arrangement with four urinals not shown in figure). Variants of this example may also include four toilet stalls (or stalls), fitting rooms, or parking spaces.

The accessibility of the urinals is checked by means of light elements, one per urinal, which are installed at the level of the urinals. If the color is red, this means that the urinal cannot be used, i.e. it is inaccessible. When it is green, it means that the urinal is available, i.e. "fully accessible". In example versions, a third color is defined, e.g., blue, when it is detected that the toilet is in use. In Example 2, no "conditionally accessible" is defined.

The control of the light elements is done by means of a service unit which is connected to a detection unit or sensor. The detection unit detects movement, and is thus able to detect the operating state ("not in use" or "in use") of each of the urinals. In example embodiments, each urinal has a separate sensor.

Upon detection of a change of the state of use of one of the urinals from "not in use" to "in use" and/or vice versa by the sensor, the service unit generates a signal indicative of said change. As a result, there is a changeover of the accessibility of one or more of the service units different from said first service unit, with different display for at least one of the light elements.

Due to the spatial geometry of Example 2, with a row of four urinals, it is advantageous to leave one urinal between each in use. This may relate to respecting a distance criterion, e.g., a norm relating to social distancing and/or the accommodating of arbitrary behavior of users in their attempt to maintain privacy. The latter may be related to, e.g., solving the urinal problem as described in (Kranakis and Krizanc).

In variations of this example, where the service units are parking spaces, it may be advantageous to leave a parking space in between each time, as this gives vehicle users (e.g., cars, bicycles, mopeds,...) more space to approach and/or park their vehicle and/or open and close the door of their vehicle.

The distance criterion in this example is characterized by grid spacing 1 ("leave one in-between"). The geometry corresponds to a first grid of urinals 1a, 1c and a second grid 1b, 1d.

The service unit drives the light elements according to a well-defined pattern, which takes into account sweep, sequence, and snap.

First, it is ensured that the workload is evenly distributed over the service units, according to a SWP principle. In embodiments, this is easily achieved, by addressing for a first busy period only the first grid, for the second busy period only the second, and for the third busy period again only the first grid, and so on. This form of allocation is a special case of sweeping, called round robin sweeping. In other implementations, a more advanced form of sweeping is employed, in which a histogram of the number of users per service unit is maintained based on said monitoring, and in which with each new busy cycle assignment is provided to the grid that meets a workload-balance criterion. Examples of workload-balance criteria are related to trying to balance the total number of turns per urinal. This relates to the SWP principle and may have the advantage of spreading cumulative wear. Other examples relate to maximizing a break between two consecutive turns per urinal. This may have the advantage of maximizing the avoidance of possible air contamination, e.g., the spread of a virus.

In addition, it is ensured not to leave a gap of two urinals, according to an SNP strategy (avoid using only distal urinals, use a maximum grid). And in doing so, it is additionally ensured that medial urinals 1b, 1c are chosen with greater preference than distal urinals 1a, 1d, according to a SEQ strategy (medial first, only then distal). In this way, it is ensured that any breakdown leads to the most advantageous new system state. Specifically, in in-a-row notation, [1,2] is more desirable than [3].

- The system state [1,2], which in the limit of low load "going to zero" is reached with certainty after a first breakdown when departing from [4], has the advantage of containing a row of two, with perfect redundancy. Thus for [1,2] allocation for first users (i.e. first of a new busy cycle) is provided to the row of two (application SEQ) and within this row of two alternating across busy cycles (application SWP).This leads with certainty in the limit of low load "going to zero" to [1,1], with still maximum capacity 2. Thus, the uptime of maximum capacity (two units) is maintained in this limit until three breakdowns have occurred.
- The system state [3] is *not* reached in the limit of low load "going to zero" after an initial breakdown. However, this system state is almost certainly reached in allocation according to random behavior, because distal urinals are preferred, see (Kranakis and Krizanc). This has the disadvantage of not including redundant pairs, only a maximal grid of two and a medial urinal in between. Again, a distal urinal is almost certainly affected by the second breakdown, see again (Kranakis and Krizanc), reaching the system state [2] after only two breakdowns, with maximum capacity reduced from two units to one unit.

Concluding, [1,2] in the limit of low load provides uptime of maximum capacity during three breakdowns, while [3] only during two breakdowns, which is a 50% improvement just by applying SEQ and SNP. Further improvement is possible by additionally applying SWP. In the high load limit,

the improvement based on probability is 12.5%, again only by applying SEQ and SNP, with further improvement possible by applying SWP. For realistic, intermediate loads, the improvement is intermediate to both limit cases.

It is also worth noting that [4] is less robust than [2,2] as an arrangement. This can be understood from the above-mentioned assignment at [4], which leads to [1,2] only at the limit of low load "going to zero", which is more advantageous than [3]. In the case of [2,2], the first breakdown inevitably causes a transition to [1,2] regardless of the load, and the less advantageous condition [3] can never occur, making [2,2] more advantageous than [3].

Example 3: five urinals - sweep (SWP), sequence (SEQ), snap (SNP) and shake (SHK)

In example embodiments according to Example 3, illustrated by Fig. 1a, the invention relates to a method similar to that of Example 2, but encompassing the further step:

- determining a workload based on said monitoring,

wherein said predetermined switchover pattern aims to achieve allocation to a maximum grid when the workload increases or remains high **and/or** where said predetermined switchover pattern aims to achieve allocation to a minimal grid when the workload decreases or remains low.

Specifically, unlike Example 2, allocation can be done to, according to the SHK principle, allocate to first users each time from the minimum grid (1b, 1d), and only from a possible second user make the switch to the maximum grid (1a, 1c, 1e). This is done in conjunction with other principles (SWP, SEQ, SNP). In this way, the probability is increased that the first breakdown is a breakdown from the minimum grid, which increases the uptime of the maximum grid. In the limit of very low load "going to zero", the previous user has always already left when the next one arrives. In that limit, 1b and 1c will fail first, and only then will the maximum grid be affected. On the other hand, in a common scenario with random user behavior, the user will typically choose a distal urinal (1a, 1e), see (Kranakis and Krizanc). As a result, in this limit, the maximum grid would already be affected from the first breakdown. Proportionally, the invention thus realizes in this limit an increase of the average uptime of the maximum grid by a factor of 3 (increase of 200%). For odd rows of length $2m+1$ this is generally a maximum improvement by a factor $m+1$. On the other hand, in the limit of full "100%" load of the maximum grid (capacity three units), the SHK principle does not apply (no improvement), because the system permanently allocates the maximum grid. For realistic load, an intermediate improvement lower than the maximum improvement applies.

When a distal urinal fails, a row of length four is obtained, and Example 2 becomes applicable.

In the case of a breakdown of a urinal 1b, 1d of the minimal grid, using in-a-row notation, [1,3] is obtained. The assignment is then made preferably first (i.e. with the first user of a busy cycle) to the row of length three (application SEQ), and within this row preferably to the medial urinal if working

with a turnaround (application SHK, chance of extra waiting) or to one of the distal urinals (application SNP) if not working with a turnaround (no application SHK, no chance of extra waiting). For a second user in the busy cycle, if any, is assigned to the one urinal of the row of length one. In case of a third user in the busy cycle, the turnaround (application SNP) to the maximum grid of the row with length three has to take place. If the first user has already left, this can be done immediately; if not, the third user must wait until the first has left. Assignment to the maximum grid is done alternately across the two distal urinals (application SWP).

In the case of a breakdown in the medial urinal 1c belonging to the maximum grid, in in-a-row notation, [2,2] is obtained. The assignment is then done alternatingly (application SWP*, i.e. "SEQ that is SWP") over the two rows, and also within the selected row alternatingly (SWP).

<u>Example 4: 1 to 10 urinals - sweep (SWP), sequence (SEQ), snap (SNP) and shake (SHK)</u>

Examples 2 and 3 only dealt with systems with one single row of length four or five, or systems derived therefrom by a breakdown. However, the strategy consisting of SWP and/or SEQ and/or SNP and/or SHK is applicable to any system of two or more units, where the strategy of Examples 2 and 3 can be applied mutatis mutandis. Below, for respective systems of size two to seven units, the applicable strategies are listed for all possible partitions, in respective paragraphs, using in-a-row notation. Systems of size eight to ten are listed in abbreviated form in subsequent respective paragraphs.

[2] SWP
[1, 1] SWP* (SEQ that is SWP)

[3] SWP SEQ* SNP SHK (only SEQ is SHK)
[1,2] SWP SEQ
[1,1,1] SWP* (SEQ that is SWP)

[4] SWP SEQ SNP
[1,3] SWP SEQ SNP SHK (SEQ\SHK not empty)
[2,2] SWP* (SEQ that is SWP)
[1,1,2] SWP SEQ
[1,1,1,1] SWP* (SEQ that is SWP)

[5] SWP SEQ SNP SHK
[1,4] SWP SEQ SNP
[2,3] SWP SEQ SNP SHK
[1,1,3] SWP SEQ SNP SHK
[1,2,2] SWP SEQ
[1,1,1,2] SWP SEQ
[1,1,1,1,1] SWP* (SEQ that is SWP)

[6] SWP SEQ SNP
[1,5] SWP SEQ SNP SHK
[2,4] SWP SEQ SNP
[3,3] SWP SEQ SNP SHK
[1,1,4] SWP SEQ SNP
[1,2,3] SWP SEQ SNP SHK
[2,2,2] SWP* (SEQ that is SWP)
[1,1,1,3] SWP SEQ SNP SHK
[1,1,2,2] SWP SEQ SNP
[1,1,1,2] SWP SEQ SNP
[1,1,1,1,1,1] SWP* (SEQ that is SWP)

[7] SWP SEQ SNP SHK
[1,6] SWP SEQ SNP
[2,5] SWP SEQ SNP SHK
[3,4] SWP SEQ SNP SHK
[1,1,5] SWP SEQ SNP SHK
[1,2,4] SWP SEQ SNP
[1,3,3] SWP SEQ SNP SHK
[1,1,1,4] SWP SEQ SNP
[1,1,2,3] SWP SEQ SNP SHK
[1,1,1,3] SWP SEQ SNP SHK
[1,1,1,2,2] SWP SEQ SNP
[1,1,1,1,2] SWP SEQ SNP
[1,1,1,1,1,1] SWP* (SEQ that is SWP)

[8] SWP SEQ SNP
[1,7] SWP SEQ SNP SHK
[2,6] SWP SEQ SNP
[3,5] SWP SEQ SNP SHK
[4,4] SWP SEQ SNP
Etc.

[9] SWP SEQ SNP SHK
[1,8] SWP SEQ SNP
[2,7] SWP SEQ SNP SHK
[3,6] SWP SEQ SNP SHK
[4,5] SWP SEQ SNP SHK
Etc.

[10] SWP SEQ SNP
[1,9] SWP SEQ SNP SHK
[2,8] SWP SEQ SNP
[3,7] SWP SEQ SNP SHK
[4,6] SWP SEQ SNP
[5,5] SWP SEQ SNP SHK
Etc.
(End of Example 4)

Examples have been given above for "stalls" or "urinals", but these terms are not limiting. They can refer to any compartmentalized service unit, where a plurality of units may consist of mutually distinct types of service units. For example, a plurality of four stalls may consist of four toilet stalls, or three toilet stalls and a sink, or four urinals, or two toilet stalls and two sinks, etc. Thus, for each example with stalls, this document discloses complementary examples where the stalls are urinals instead, and/or vice versa.

Claims

1. Method for controlling an accessibility with respect to a plurality of compartmentalized service units (1a-1e) related to toilet facilities, said method comprising the steps:

   – monitoring a state of use of a first of said service units;

   – upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa; generating a signal indicative of said change;

   – upon detection of said signal, switching the accessibility of a second of said service units different from said first service unit;

   whereby said switching of accessibility of the second service unit occurs between at least two of a plurality of accessibility modes including at least two of "fully accessible", "conditionally accessible", and "inaccessible".

2. Method according to claim 1 , wherein said monitoring of the state of use includes monitoring of said second service unit.

3. Method according to claim 2, wherein the first monitored service unit belongs to a first grid and the second monitored service unit belongs to a second grid which is arranged staggeredly with respect to the first grid, and wherein said switching of accessibility of the second service unit and preferably also the first service unit occurs when a condition related to a predetermined switchover pattern is satisfied, and does not occur when said condition is not satisfied.

4. Method according to claim 3, comprising the further step:

   – determining a histogram of number of users per service unit based on said monitoring,

   where said predetermined switchover pattern aims to distribute a workload evenly among the service units.

5. Method according to claims 3- 4, comprising the further step:

   – determining a workload based on said monitoring,

   wherein said predetermined switchover pattern is aimed at achieving allocation to a maximum grid when the workload increases or remains high
   and/or

   wherein said predetermined switchover pattern aims to achieve allocation to a minimal grid when the workload decreases or remains low.

6. Method according to claims 3 - 5, where said switchover pattern corresponds to a windshield wiper pattern or a maximum-switchover pattern.

7. Method according to claims 1-6, wherein said plurality (1a-1e) comprises one or more rows of service units, wherein said monitoring of the state of use comprises monitoring of all service units, and wherein, upon detection of the state of use "not in use" for all service units, a service unit is made accessible being
   - if the plurality comprises a row of even length, a service unit belonging to said row of even length, and if not, a service unit belonging to a row of odd length with respective greatest odd length
   and/or
   - a service unit (1b;1c;1d) which is medially located with respect to a respective first (1a; 1b; 1c) and a respective second immediately neighboring service unit (1c; 1d; 1e).

8. Method according to claims 1-7, wherein said predetermined switchover pattern is directed at realizing assignment to a service unit belonging to a pair of service units whereby any breakdown of either unit does not reduce a maximum capacity.

9. Method according to claims 1-8, where said allocation is made with lower preference to a distally located unit (1a, 1e) than to a medially located unit (1b-1d).

10. Method according to claim 9, wherein said allocation to said medially located unit (1b-1d) is further done with lower preference than to a redundant unit.

11. Method according to claims 1-10, wherein said access mode "conditionally accessible" is related to a distribution of a workload according to a triage parameter defining a first and a second subpopulation, wherein one of the two subpopulations is granted access and the other of the two subpopulations is not, wherein said detection is related to the change from said "not in use" to said "in use", and wherein said switching of accessibility occurs from said "conditionally accessible" to "more accessible", preferably from said "conditionally accessible" to "fully accessible".

12. Method according to claims 1-11, comprising the further steps:

    - providing a kiosk to a user;
    - generating, by the kiosk and at the request of the user, of a triage parameter applicable to said user;
    - disclosing the triage parameter to the user, preferably displaying said triage parameter to the user.

13. Method according to claim 12 , wherein said generating of the triage parameter is at least partially based on a workload measurement at the level of one or more of the service units.

14. Method according to claim 13, comprising the further step:

- determining a feature that relates to the user, preferably a feature of an access ticket of the user, e.g., by scanning the access ticket of the user and/or a feature of the user;

wherein said generation of the triage parameter is at least partially based on said feature.

15. Method according to claims 1-14, wherein said change of said state of use is done from "in use" to "not in use", wherein said method includes the further step:

    - upon detection of said signal, also switching the accessibility of the first service unit from said "conditionally accessible" or "fully accessible" to "inaccessible".

16. Device for controlling an accessibility related to a plurality of compartmentalized service units (1a-1e) related to toilet facilities, said device comprising:

    - a service unit;
    - a sensor;
    - means of switching the accessibility of a service unit;

    wherein said device is configured to perform the steps of:

    - monitoring, using said sensor, a state of use of a first of said service units;
    - upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa; generating, by means of said service unit, a signal indicative of said change;
    - upon detection of said signal, switching, by said means of switching the accessibility, the accessibility of a second of said service units different from said first service unit;

    whereby said switching of accessibility of the second service unit occurs between at least two of a plurality of accessibility modes including at least two of "fully accessible", "conditionally accessible", and "inaccessible".

17. Device according to claim 16, wherein said sensor relates to a motion sensor or a door sensor mounted on a door or in the vicinity of said first service unit and wherein said means comprises a visual indicator, preferably a screen or a colored light source such as a green or red LED, at the height of the second service unit and/or wherein said means comprises a door lock/unlock of a door of said second service unit.

18. Use of a plurality of devices according to claims 16-17, wherein said devices are arranged in series so that a first device based on monitoring of a first service unit controls the accessibility of a second service unit, a second device based on monitoring of at least the second service unit controls the accessibility of a third service unit, and so on.

19. System for controlling an accessibility related to a plurality of compartmentalized service units (1a-1e) related to toilet facilities, said device comprising:

    - a service unit;
    - a plurality of sensors, one per service unit;
    - means of switching the accessibility of each of the service units;

    wherein said device is configured to perform the steps of:

    - monitoring, using said plurality of sensors, a state of use of each of said service units;
    - upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa of at least one service unit, calculating, by the service unit, whether a switch of accessibility of at least one service unit is desirable, preferably based on a predetermined switch pattern;
    - if a changeover is desired, the generation, by means of said service unit, of a signal indicative of said change;
    - upon detection of said signal, switching, by said means of switching the accessibility, the accessibility with respect to the at least one service unit for which switching is desired;

    wherein said switching of accessibility of the at least one service unit occurs between at least two of a plurality of accessibility modes comprising at least two of "fully accessible", "conditionally accessible", and "inaccessible".

20. Method for providing a triage parameter to a user, including the steps of

    - monitoring a state of use of a plurality of service units in a building;
    - providing a kiosk comprising a kiosk application to a user;
    - generating, through the kiosk, at the request of the user, and based on at least said monitored states of use, a triage parameter applicable to the said user;
    - disclosing the triage parameter to the user, preferably displaying said triage parameter to the user, which is associated with a group of service units in the building.

21. Kiosk configured to perform the method according to claim 20.

22. System comprising one or more kiosks according to claim 21 and a back-end server, said system being configured to perform a method according to claim 20.

ARRANGEMENT AND ORGANIZATION OF TOILET FACILITIES

Abstract

The invention relates to a method for controlling an accessibility with respect to a plurality of compartmentalized service units related to toilet facilities, said method comprising the steps: monitoring a state of use of a first of said service units; upon detection of a change of said state of use from "not in use" to "in use" and/or vice versa; generating a signal indicative of said change; upon detection of said signal, switching accessibility of a second of said service units different from said first service unit; wherein said switching of accessibility of the second service unit occurs between at least two of a plurality of accessibility modes comprising at least two of "fully accessible", "conditionally accessible", and "inaccessible".

Figures

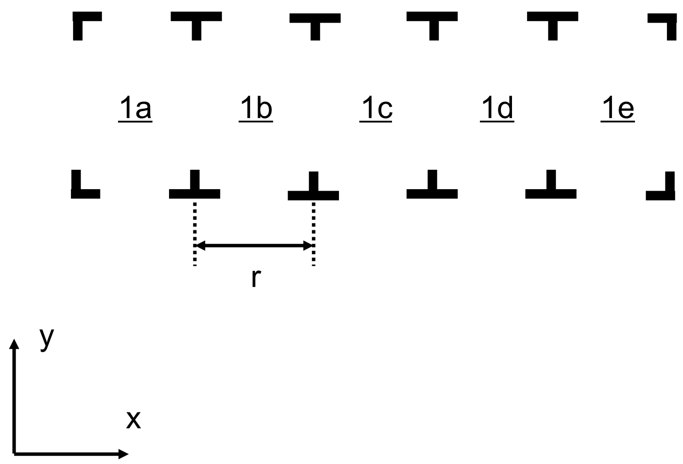

Figure 1a

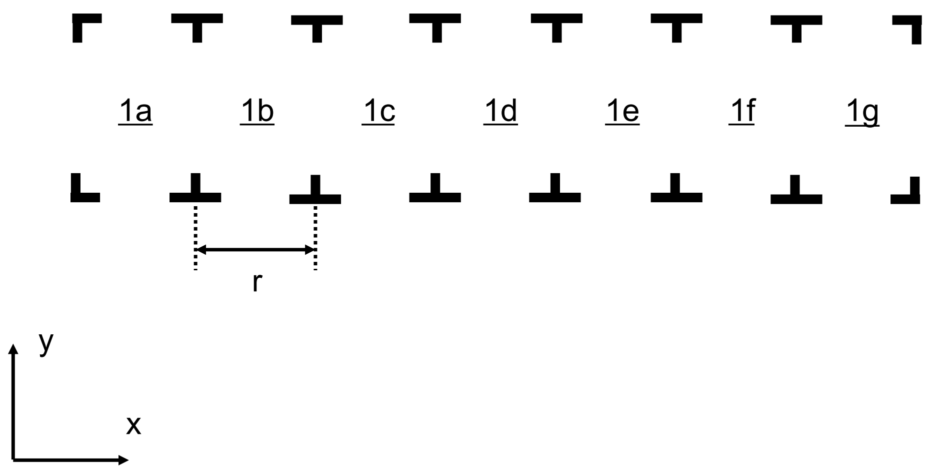

Figure 1b

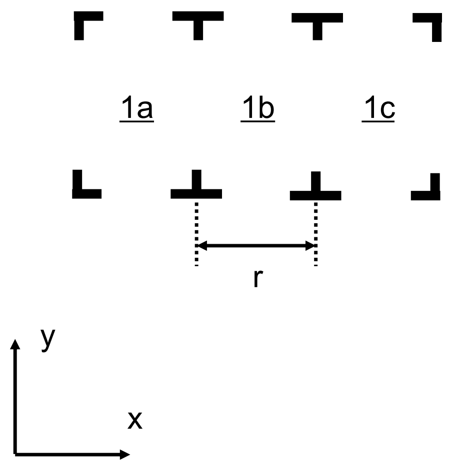

Figure 1c

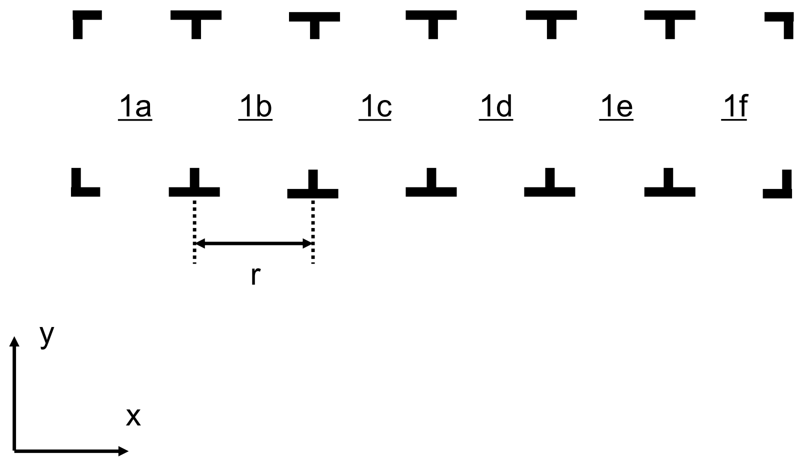

Figure 1d